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Progress Report 3712-8

DRYLAND PASTURE AND CROP CONDITIONS AS SEEN BY HCMM

Progress Report for Period
October 1979 - February 1980

Prepared for

NASA-Goddard Space Flight Center
Greenbelt, Maryland 20771

Contract NAS5-24383

TEXAS A&M UNIVERSITY
REMOTE SENSING CENTER
COLLEGE STATION, TEXAS

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DRYLAND PASTURE AND CROP CONDITIONS AS SEEN BY HCMM

By

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1.0 BACKGROUND AND SUMMARY

1.1 Background

This 32-month project is an extension of several other projects which involve estimates of wheat yield (Harlan et al., 1978), green biomass (Deering et al., 1977) and watershed run-off coefficient (Blanchard, 1978) using visible, near infrared and passive microwave data. In each estimate, soil moisture content is a major determining factor. The hypothesis of this study is that high resolution thermal infrared data, such as those received from HCMM, will enchance estimates of soil moisture content. Therefore, the three objectives of this project, as given in the statement of contract NAS5-24383, are:

1) to assess the capability for determining wheat and pasture canopy temperatures in a dryland farming region from HCMM data.

2) to assess the capability for determining soil moisture from HCMM data in dryland crops (winter wheat) from adjacent range lands.

3) to determine the relationship of HCMM-derived soil moisture and canopy temperature values with the condition of winter wheat and dryland farming areas during the principal growth stages.

To accomplish these objectives, measurements will be obtained at three levels: ground truth, aircraft, and satellite. The site selected for these measurements are on the

Washita River watershed, near Chickasha, Oklahoma. The area has a dense USDA/SEA-AR network of rain gauges, and rangeland and dryland winter wheat are often adjacent to each other. Ground truth data include canopy and lake surface temperatures, neutron probe and gravimetric soil moisture samples, and daily precipitation data. The aircraft collected day/night thermal scanner data and aerial photos of commercial wheat and pasture fields; HCMM has collected day/night thermal imagery over the same site in addition to a site near Colby, Kansas. Data collected from each level will be correlated in three ways:

1) thermal (HCMM and aircraft) parameters of soil moisture and crop canopy temperatures will be derived,

2) a technique will be developed to calculate the antecedent precipitation indices from the thermal parameters of soil moisture and canopy temperatures, and

3) an input parameter for yield prediction models will be developed.

1.2 Summary

Accomplishments during the eighth period of the contract (October 1979 – January 1980) include:

1) Arrival and analysis of HCMM tapes and images over Chickasha, Oklahoma, and Colby, Kansas,

2) Association of daytime HCMM thermal IR data to API and precipitation, and

3) Presenting a brief review of project results to the project manager at NASA/GSFC in January.

Fifteen additional tapes were received during this period, bringing the total to twenty-five. Greymaps of the test site were produced from each tape. Several tapes over Chickasha include 36-hour day/night coverage. Two 12-hour day/night passes were ordered for the Colby area.

Two day thermal IR images, each under different API conditions, were compared and found to be associated to API. In addition, precipitation gradients were compared to daytime thermal gradients within three days after a large storm passed through the area. Three cases at Chickasha, Oklahoma; Colby, and Garden City, Kansas, will be presented.

On January 10, a brief review of project results were presented to project managers at NASA/GSFC.

2.0 ACCOMPLISHMENTS AND PROBLEMS

2.1 Accomplishments

During the eighth period, HCMM data analysis began in earnest with receipt of several tapes. Twenty-five CCT's are now on inventory--3 covering western Kansas and 22 covering the Chickasha area. Computer greymaps of the digital thermal data from the test site were produced from each tape.

Precipitation data was also received for the overpass periods at Kansas and Oklahoma. Contour rainfall maps were also produced for storms which covered part of our interest area. At Chickasha, data from 168 rain gauges were used; near Colby, 39 rain gauges in the eastern part of the county were used. API values were calculated for areas along the flight-lines flown in May 1978, at Chickasha. The thermal infrared information was then compared to the precipitation and API (Antecedent Precipitation Index) maps. Four areas will be described in the following section.

2.2 Future Accomplishments

Additional 1979 precipitation data has been requested from Oklahoma. The type of data involved are storms occurring over part of the watershed. Imagery and tapes (HCMM and/or TIROS-N) immediately before and after the storms will be ordered. The storm dates which will be related to the satel-lite data are May 20, June 8-9, July 16, and August 19-22.

2.3 Problems

The only problem is getting our hands on 12-hour day/night registered thermal data over Oklahoma and Kansas. Two dates over the western Kansas site were ordered a month ago, while no clear 12-hour combinations have been detected over the Oklahoma site. Other possible thermal reference images will also be analyzed. This includes comparing two daytime IR scenes and comparing the daytime thermal IR scene to constant night surface temperatures as suggested by Dr. J. Price of GSFC.

3.0 SIGNIFICANT RESULTS

During the eighth period of the contract we received 15 CCT's covering the Chickasha area. Two of them involve a 36-hour day/night pass. This brings the present inventory to 25 CCT's and 170 images.

Analyzing some of the images and tapes, several thermal patterns were detected which were exclusive to that image. These anomalies were found to be highly related to recent precipitation patterns. Three cases will be presented in this report. During the next period, we will look for small-scale rain storms (less than 10 km wide) passing over the Washita Watershed in Oklahoma and the Colby, Kansas, area in 1979 and order the corresponding images and CCT's (HCMM and TIROS-N).

Day/Day Thermal Data vs. API

A Chickasha IR scene having a wide range of 30-day API across the watershed ($\leq$ 10 cm) was compared to a Chickasha IR scene having uniform API (0.5 cm). Certain areas having high API and high thermal differences appeared to correlate well. Figure 1 represents a thermal IR greymap of the Chickasha area on June 11, 1978. The two flight lines are also shown as dark lines on the image. The temperature range on this scene is 296 to 299°K. Note area A, which has a fairly high temperature (~299°K). Areas B and C are

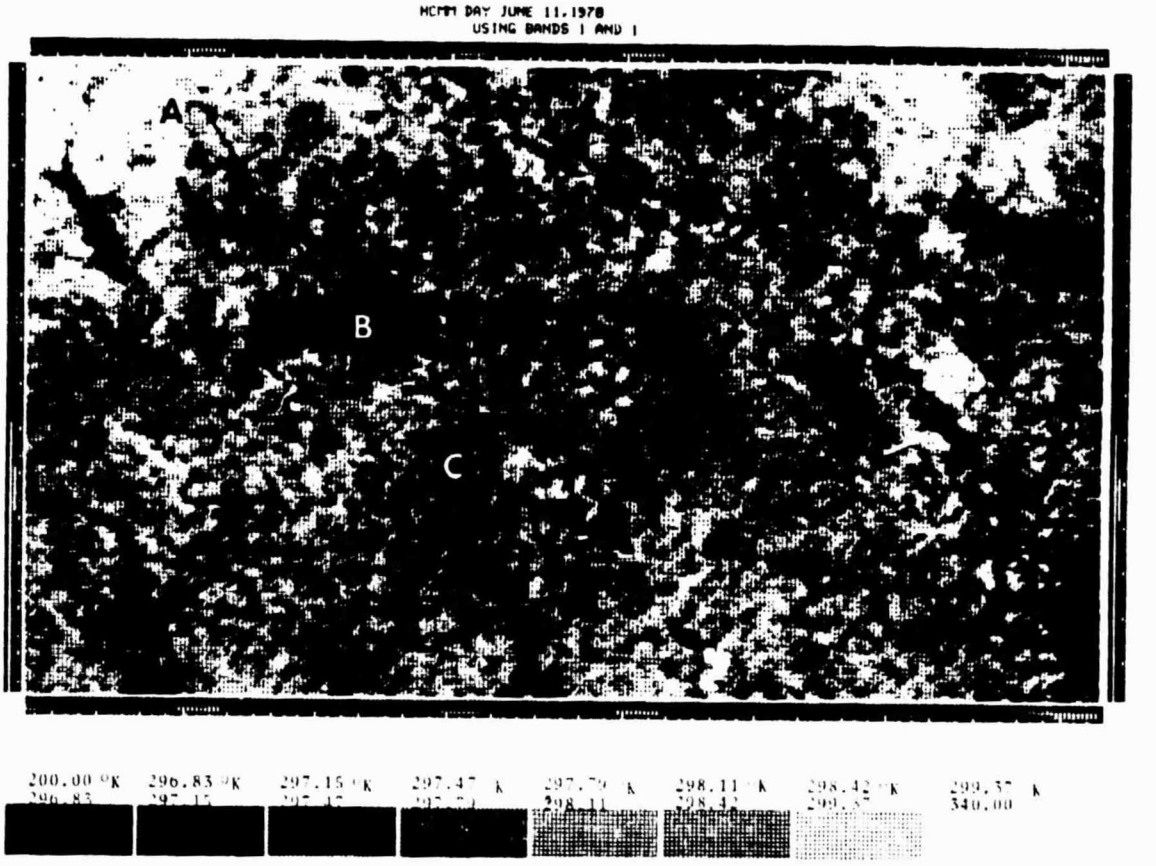

Figure 1. Daytime thermal IR greymap of the Chickasha area on June 11,1978. Ft. Cobb Reservoir is the dark area in the upper left hand corner; Lake Chickasha is just to the right of area 'B'.

relatively quite cool (296°K). Analysis of the 30-day API data for the area (Figure 2) shows the highest value is in the southern part of the east flight line; the lowest value is in the northern part of the west flight line. This region matches reasonably well with areas C and A of Figure 1, respectively.

Since no 12-hour later night image was received in conjunction with this image, we searched for an image having uniform conditions along both flight lines. November 2, 1978, was a date with such conditions. Along both flight lines, the 30-day API value was approximately 0.50 cm (Figure 3). The corresponding daytime thermal IR conditions are shown in Figure 4. The flight lines are shown as black lines on the greymap. Areas A, B, and C correspond to the same areas on the June 11 image. The two dates have not been calibrated using lake surface temperatures; however, they do have the same temperature range (3°C). Note that area A is quite cool, B is relatively warm, and C is quite warm. Taking differences between the two day images, we obtain a direct relationship between thermal differences and API (a 4°C temperature difference corresponding to a 5 cm API difference). This relationship is based on the assumption that the percentage of vegetated areas are approximately the same in both images. Diurnal temperature ranges vary throughout the year in relation to variations in insolation. Consequently,

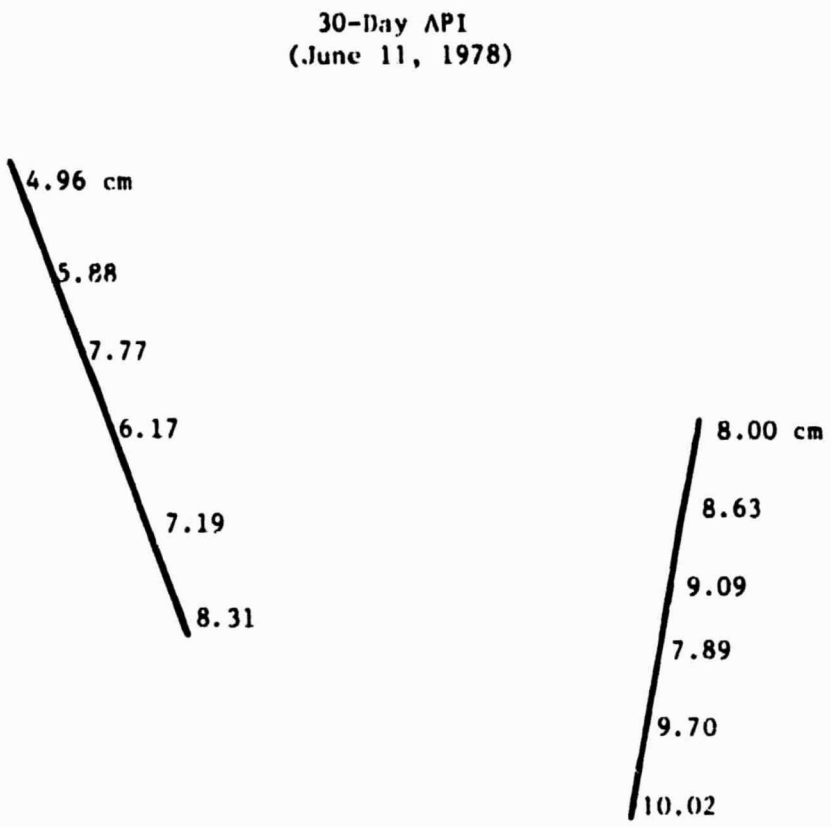

Figure 2. 30-day API values for June 11, 1978 along the west (left line) and east (right line) flight lines.

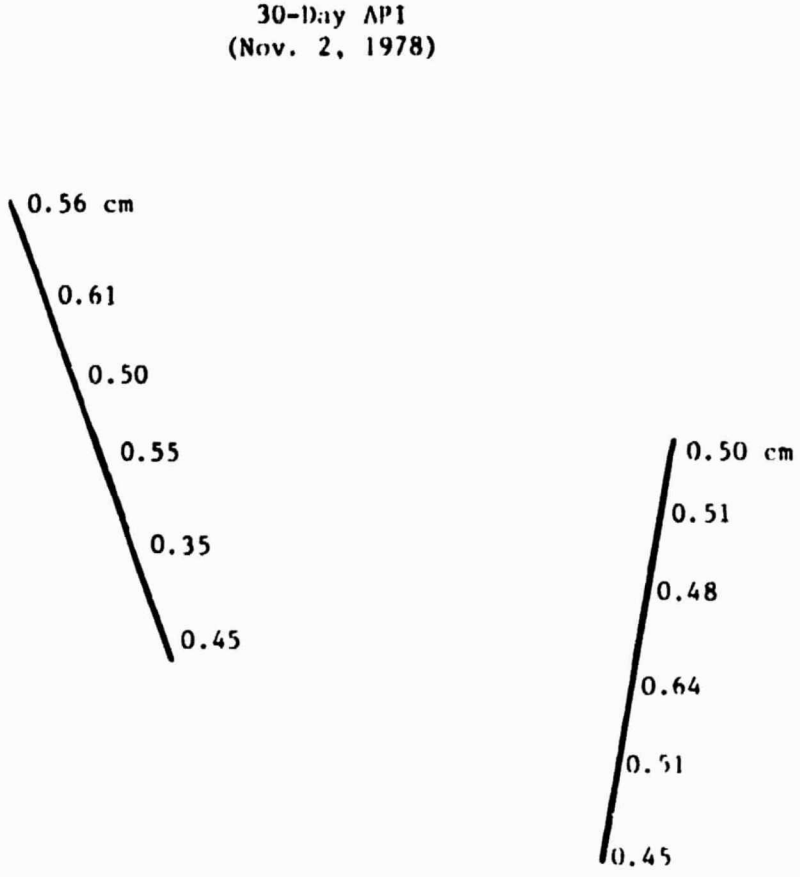

Figure 3. 30-day API values for November 2, 1978, along the west (left line) and east (right line) flight lines.

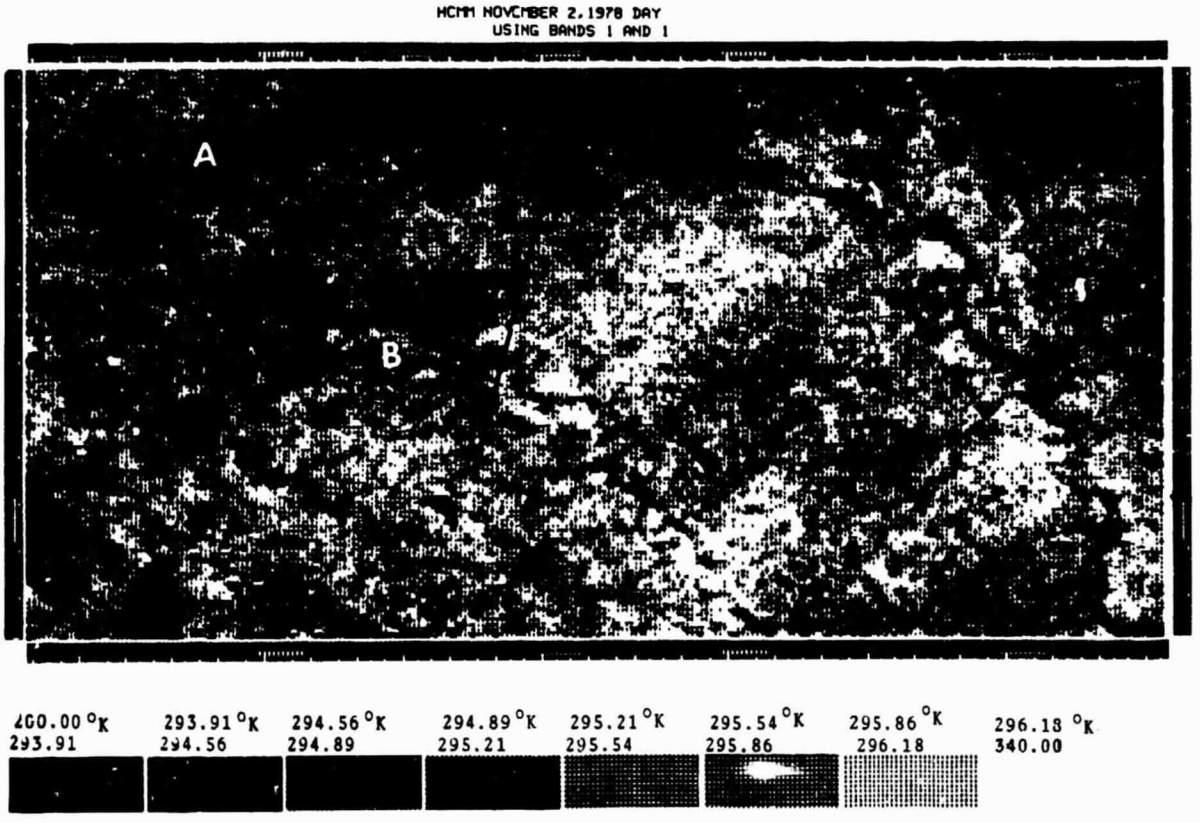

Figure 4. Daytime thermal IR greymap of the Chickasha area for November 2,1978. Ft. Cobb Reservoir is the dark area to the left of 'A'; Lake Chickasha is just to the right of area 'B'.

insolation will be used as the normalization factor.

The optimum case would be to compare thermal IR data immediately before and after a given storm. Ground conditions (amount of vegetative cover, soil type, etc.) and insolation would be approximately the same on both dates.

Precipitation Gradient vs. Thermal Gradient

Precipitation gradients from two storms in Oklahoma and Kansas were related to corresponding HCMM thermal IR gradients.

On July 22, 1978, a small storm moved across part of the Washita Watershed leaving as much as 7.0 cm in the storm path, while other areas received no rain. The storm was approximately 25 km wide. A contour map of the storm is given in Figure 5. The major storm track extends southwest to northeast. The affected area is south of Andarko, through Lake Chickasha (area A) extending northeast toward Oklahoma City.

Two days later, clear-day HCMM data was received. The thermal IR greymap is shown in Figure 6. Note the dark, cool band extending from the lower left-hand corner through Lake Chickasha to the northeast. The region of heaviest precipitation is also the coolest. Areas A and B correspond to the areas receiving 6.4 -- 7.6 cm. Note the similarity between the rainfall and thermal patterns. Smaller amounts of precipitation have warmer, lighter signatures. The dark,

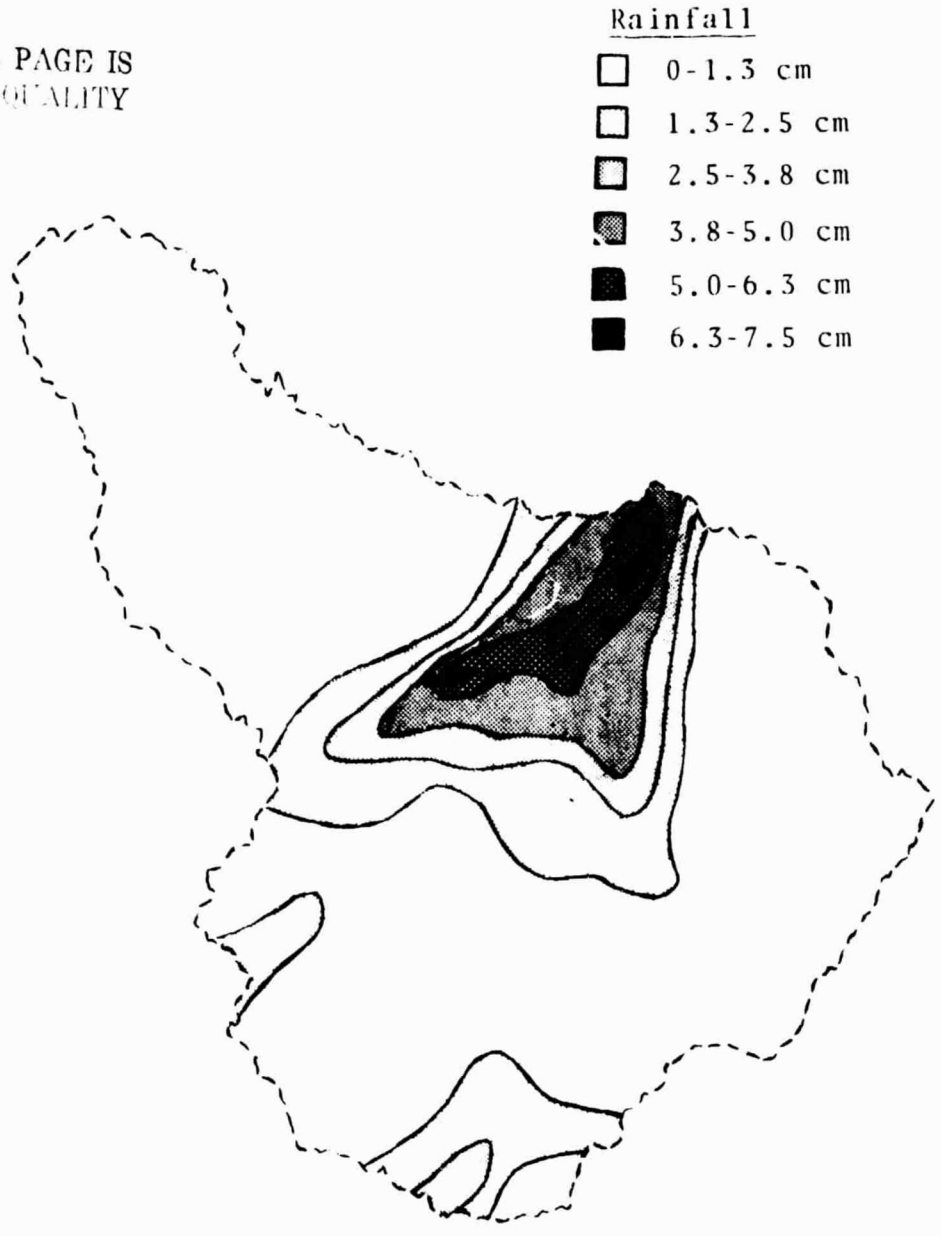

Figure 5. Rainfall contour map of the storm over the Washita Watershed area on July 22, 1978.

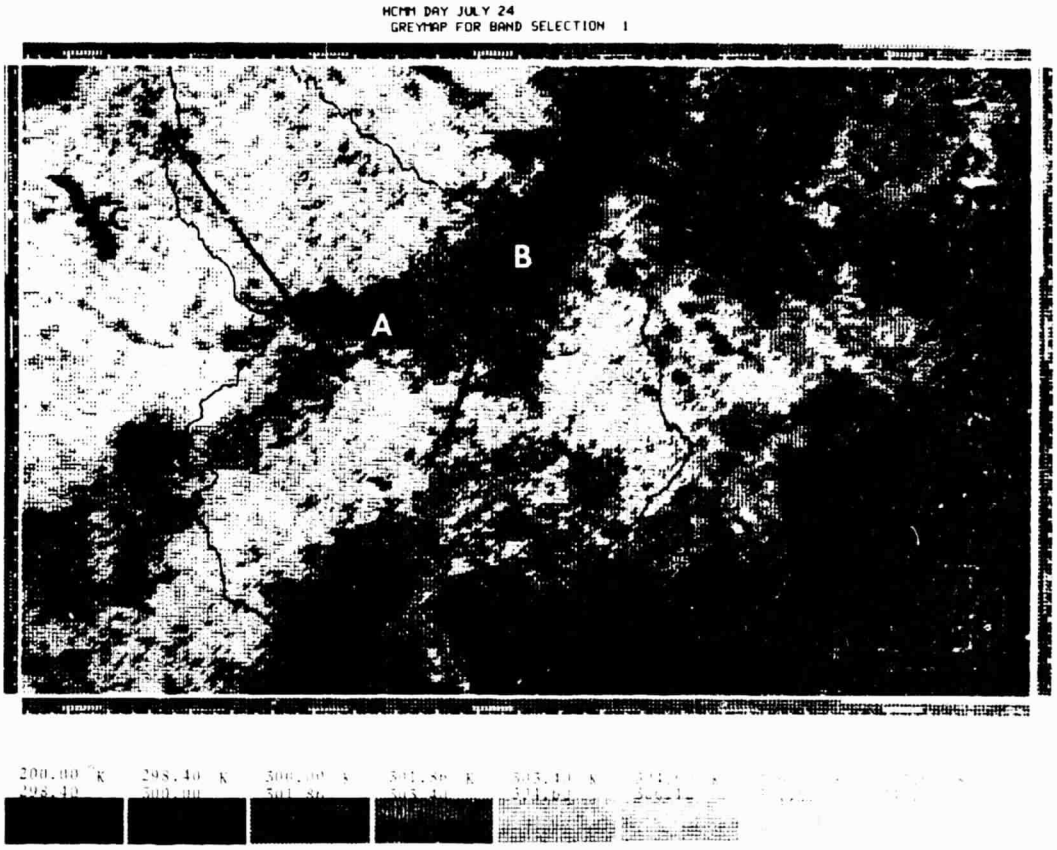

Figure 6. Daytime thermal IR greymap of the Washita Watershed area (outlined on the map) acquired on July 24,1978. Points A and B correspond to the areas receiving 6.4-7.6cm of rain on the contour map (Figure 5).

cold areas at the bottom of the image are clouds. The 7 cm rainfall induced a 6°C temperature drop compared to areas receiving less than 1.25 cm of rain. Comparisons with an IR image immediately before the storm will provide a stronger basis for determining the precipitation/thermal relationship and the precipitation limit which can be detected. Nimbus-5 thermal images of the area prior to the storm have been ordered. Also, the data should be normalized using insolation data.

A second example was noted in the August 15 storm over western Kansas. Two areas, Colby and Garden City, will be discussed. Figure 7 is a contour map of the storm just southeast of Colby. Precipitation ranged from 0-2.5 cm in the area with increasing rainfall with distance as the storm traveled eastward. Figure 8 represents thermal IR greymap of the area described in the contour map. The data were collected on the same date as the storm. First note the decreasing temperature with increasing rainfall. The temperature gradient of 8.1°C corresponds to the 0-2.5 cm precipitation gradient. No definite explanation can be given as to why the river basins are warmer than the surrounding area. One possible reason is differences in soil type--sandier soil in the river basin having a higher thermal conductivity than clay soil. No explanation can also be given for the cool areas in the top part of Figure 8, where rainfall was less

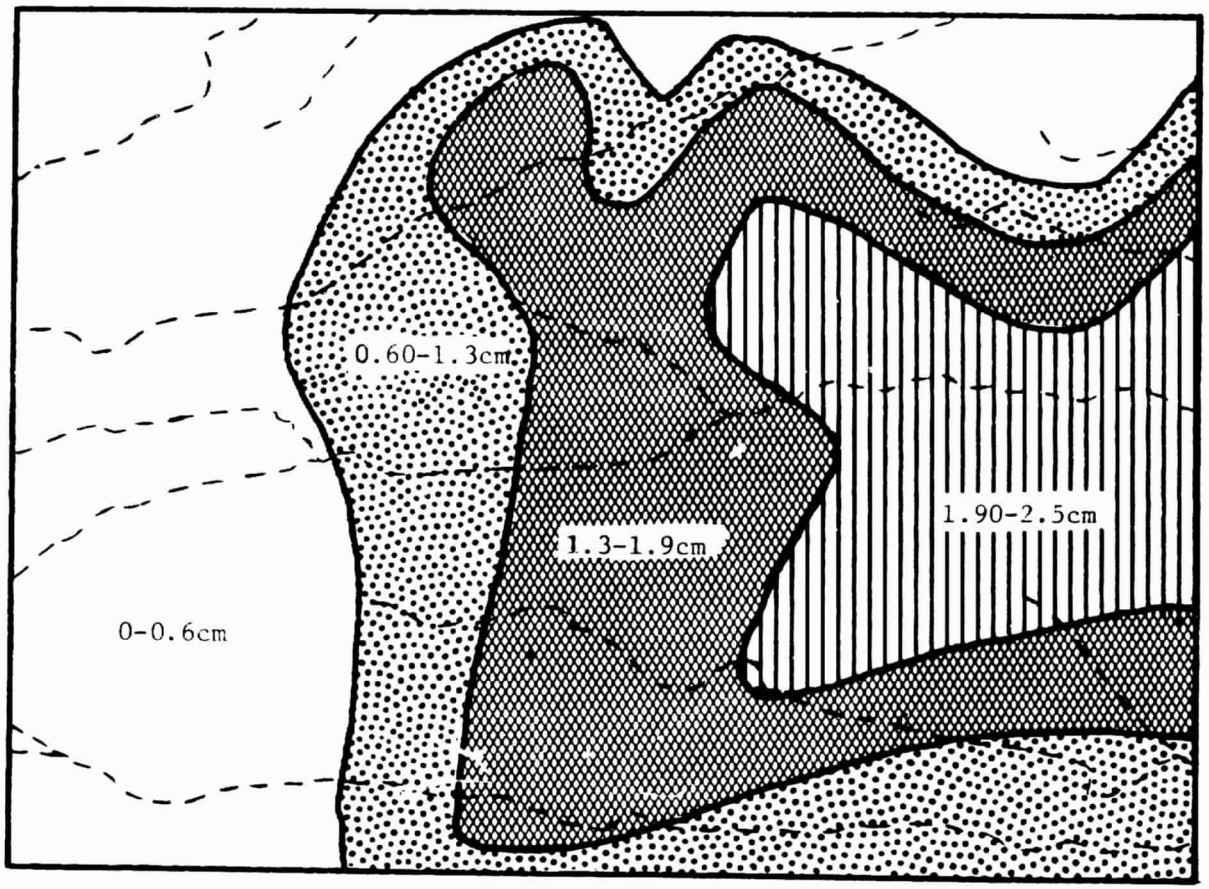

Figure 7. Rainfall contour map of the storm over Colby, Kansas, on August 15, 1978.

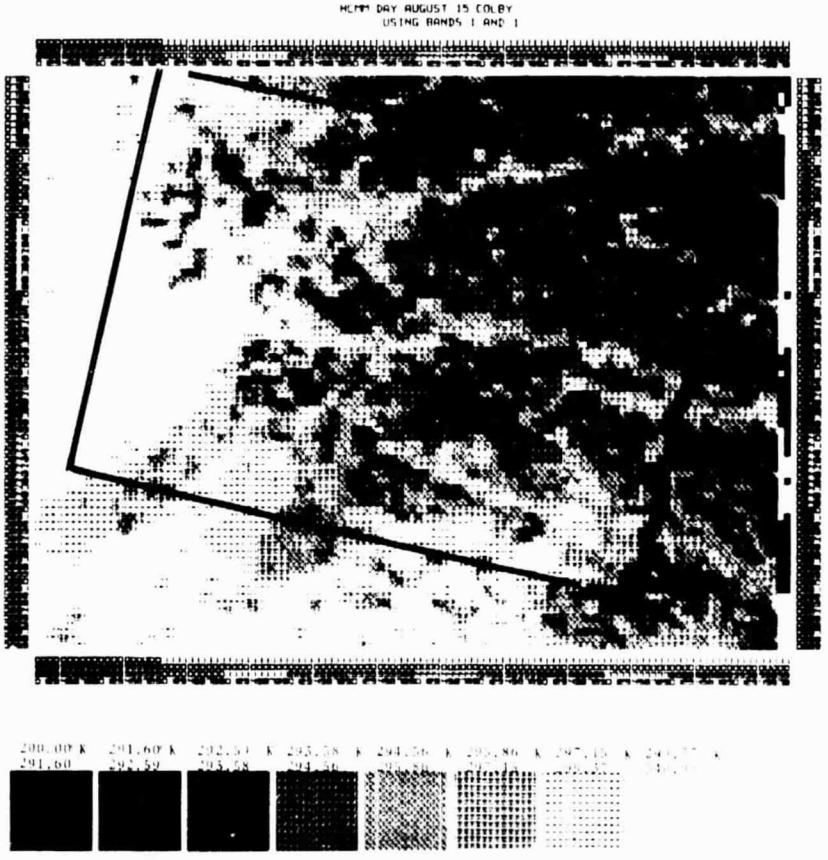

Figure 8. Daytime thermal IR greymap of the Colby area on August 15, 1978. The contour map of Figure 7 is outlined on the greymap.

than 0.6 cm. An image preceeding the storm is needed for comparisons with this image. This would provide an indication of surface conditions before the storm.

Also on this date a small storm passed close to Garden City. The IR greymap of this area is shown in Figure 9. Garden City is shown as 'A' on the map. The weather station at the Experiment Station just northeast of town received only a trace of rainfall. Kalvesta (area B on the greymap), a town 25 miles northeast of the experiment station, received 2.5 cm on that date; Jetmore (area C on the greymap) received 3.3 cm on that date. Note the distinct cool band which extends from southwest to northeast. The width of this band increases with distance traveled to the northeast, corresponding to the increasing size of the storm (from about 5 to 25 km). The temperature gradient corresponding to the 3.3 cm precipitation gradient is 10.6°C. The two storms at Colby and Garden City both induced an 8°C temperature drop for a 2.5 cm rainfall.

Because of the inability to obtain clear 12-hour day/night HCMM IR imagery, we will attempt to compare day IR imagery before and after a given storm. TIROS-N will be viewed as an additional IR data source (day and night). Storms occurring in 1979 over either HCMM sites will be analyzed. Storm sites being analyzed for Chickasha are: May 20, June 8-9, July 16 and August 19-22. Satellite thermal IR data (TIROS-N and HCMM) covering the area during these periods will be ordered.

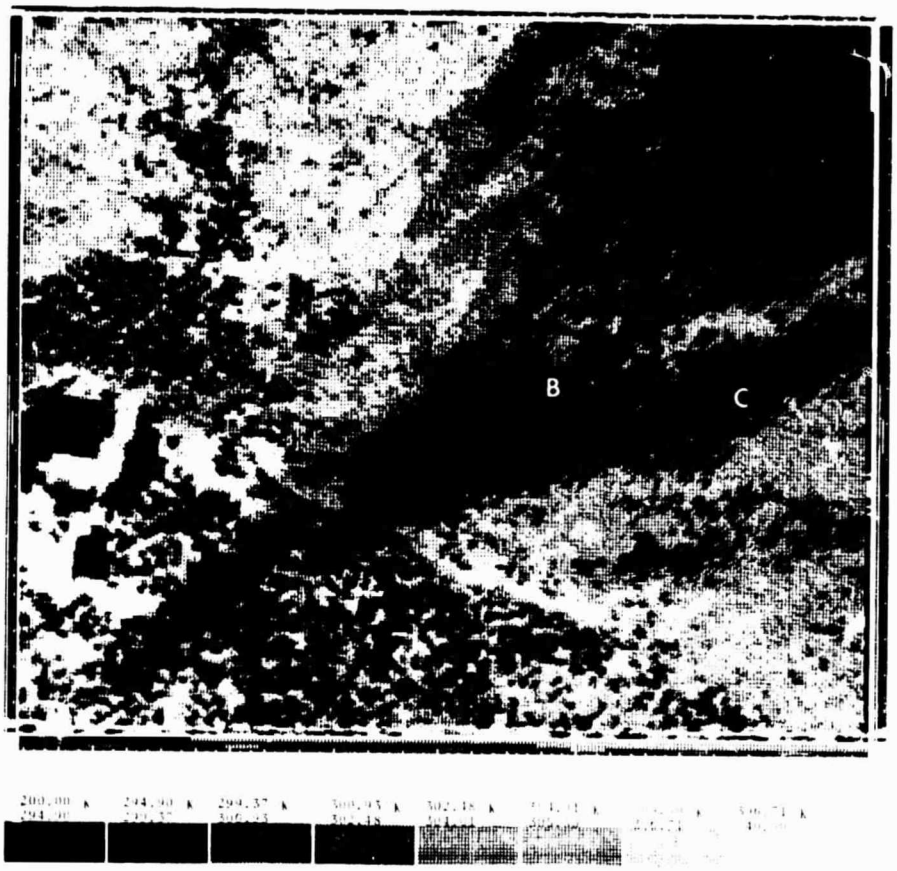

Figure 9. Daytime thermal IR greymap of the Garden City, Kansas area on August 15,1978. Points A, B, and C represent the towns of Garden City, Kalvesta, and Jetmore, respectively.

4.0 FUNDS EXPENDED

During the eighth period (October 1979 - January 1980), a large part of the money was spent on travel. A trip to GSFC in January was a major portion of this expenditure. During this quarter, $7,018 was spent, bringing the total amount to $68,054, or 78% of the total budget. During the next period, computer processing of the CCT data will comprise a large portion of the expenditure. Table 1 gives a breakdown of the funds expended.

TABLE 1

Funds Expended

	First Four Quarters	Fifth Quarter	Sixth Quarter	Seventh Quarter	Eighth Quarter
Supplies	537	40	115	0	55
Travel	3,224	0	0	268	1,745
Other Direct Costs	9,600	1,724	385	175	217
TOTAL OTHER DIRECT COSTS	13,361	1,764	505	443	2,017
Salaries and Wages	19,083	5,913	0	5,967	3,447
TOTAL INDIRECT COSTS	8,668	2,626	0	2,806	1,554
	41,012	10,303	505	9,216	7,018

5.0 AIRCRAFT AND SATELLITE DATA USAGE

All ordered CCT's have good quality, and can be processed on our TI980 computer.

Since we will be comparing day images over a given area, some data registration may be needed. We are looking into this need and will develop software to calculate daytime thermal differences.

Because of the varying contrast of thermal IR as a function of the season, we will attempt to normalize the thermal data using solar radiation and thus compare thermal differences between seasons of the year.